Mass motorization in China

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Abstract

Purpose – The purpose of this paper is to give an answer to the questions whether China can make the quantum leap in automotive technology from engines that burn fossil-fuel to those that do not and whether China will take an "alternative Asian path of development."

Design/methodology/approach – This paper is based on a sociological approach to prove potential technical innovations reflecting the social conditions of radical innovations like post-fossil mobility concepts.

Findings – Innovations like a post-fossil car concept consist of more than new technical infrastructures and mere imitations, they require decentralized spaces for incubation and experimentation. Translated into conditions governing the policy milieu, that need means that potential promoters of innovations need fundamental political freedoms, equality before the law, legal certainty, and the advancement and protection of personal rights *vis-à-vis* the state. In a sociological perspective, China needs social modernization in the sense of differentiation, individualization, and internalization of external constraints.

Research limitations/implications – This paper reflects the opportunities and restrictions of radical change in car technology in china. It does not give evidence for the future of conventional mass motorization as the continuance of the state of the art in car technologies.

Practical implications – This paper implies – as a practical consequence – that the established car industry in the triad is furthermore responsible for progress in car and motor concepts being more energy efficient and less dependent from oil.

Originality/value – The original contribution of this paper is that it connects the technical debate on the future of cars and their drive system with the discussion of social and political terms of collective capacity of radical innovations.

Keywords Automotive industry, Automotive fuels, Innovation, Fossil fuels, China

Paper type Research paper

The era of cheap oil is over. The search for alternatives has long since begun in the automotive industry's research and development (R&D) labs. It is not clear what technology will finally win out as the successor to the conventional internal combustion engine. Nor is it evident what the dominant fuel will be. Can China make the quantum leap in automotive technology from engines that burn fossil-fuel to those that do not? Can that country thereby lead the field and set the standards in the automobile industry of the future? Crude oil will not last forever as the basis of high-energy systems. The greater the short- and medium-term demand for oil in the rapidly growing economies of Asia, South America, and eastern Europe, the shorter that period will be. Another reason for the importance of answering the question about the future of automotive technology is that China's all-out push to catch up on conventional motorization is a recipe for ecological disaster.

A full treatment of the argumentation presented in this article is contained in W. Canzler, M. Dierkes, A. Knie, L. Marz, and M. Weider (2008), *Verpasste Chances der Modernisierung? China zwischen nachholender und alternativer Motorisierung* [*Missed Opportunities of Modernization? China between Catch-up and Alternative Motorization*] (Berlin: edition sigma).

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A paradigmatic shift in automotive technology and the foundation of its energy system would shake, possibly even revolutionize, the established automotive industrial complex in the triad countries (the USA, Japan, and the Eurozone. The reasons for and against this kind of avant-garde role for China are therefore worth discussion. It is time to consider whether an ambitious change of technological paradigm in the Chinese automotive industry is realistic. A fairly close look at the country and its miraculous growth reveals a host of ambiguities and disequilibria. The conditions for technologically leaping ahead turn out to be very uncertain. The risk that the Chinese economy will overheat is high, and diverging economic, social, and regional forces can lead to serious distortions. More than anything, the widening gap between the wealth of the few and the poverty of the many is straining the cohesion of Chinese society, making a comprehensive stabilization policy the highest priority for China's leaders. Even if they manage to balance the nation's economic and social disequilibrium and achieve "sustainable growth," and even if a burgeoning middle class ensures stable domestic demand, no one knows what consumption patterns will develop. So far, demand for durable goods has been surprisingly unconducive to innovation – which is defined in this paper as the intent and ability to create something genuinely new and not just to imitate something that already exists or to utilize it in a new way. Chinese buyers have preferred tried-and-tested commodities from the west. The product-related models inherited from the early industrialized world persist.

Since the late 1970s, China has undergone headlong economic development, at least in the Pacific coastal regions. Thanks to high growth rates, the national economy has joined the ranks of the word's leading economic powers, and nothing indicates that the country's meteoric rise will end anytime soon. Industry will continue propelling it for the foreseeable future. With an unprecedented focus on world markets, China's economic modernization in the last quarter of a century has centered on pulling even with the developed world's level of industrialization. The world is witnessing in China a massive surge in forces of production within the framework of a logistically ultraefficient and globally networked, computerized type of capitalism under the management of an authoritarian national political party. Simultaneously, the resource-intensive, consumption-oriented western life style is spreading in China's expanding middle class, with severe economic and ecological impacts. Demand for natural resources and food, especially meat and fish, is driving up prices, and noxious emissions are increasing, particularly in the transport sector. Whereas China's export industry once accounted for a major share of the pollution caused by industry and the transport sector, "home-made" environmental pollution is becoming ever more significant.

Motorized transport is a twofold issue. Not only does it emit toxins and noise locally, the carbon dioxide in automotive exhaust exacerbates global climate change. The car as known today, used as it is on a massive scale, is not only an ecological problem child but also a special article of consumption. No other technical device promotes social processes of differentiation more distinctly or evokes as many desires, dreams, and illusions of omnipotence as the car does.

China – pioneer of mobility without fossil fuels?

In addition to the fact that Chinese households have been equipping themselves with conventional cars for some time now, a possible and desirable scenario exists: the

adoption of a radically different kind of automotive technology that both husbands scarce resources and protects the environment. Research strategies and industrial policies for building a mobility industry that avails itself of technology no longer dependent on fossil fuels are definitely plausible in China. The need to shed existing know-how and to abandon an infrastructure that has drawn on such energy sources for decades would be less there than in countries with an established car industry. Given the looming depletion of fossil energy resources, nothing less than economic sustainability is at stake. Hydrogen is currently thought to have the best chance of emerging as the key future source of energy for most purposes, including transport (Sperling and Cannon, 2004). Ultimately, however, the way in which hydrogen is to be produced will decide its character after overall reliance on fossil fuels ends. In other words, hydrogen can be a post-fossil-fuel only if it is generated from completely renewable sources – nothing but a remote possibility at this time. In this paper, mobility in the post-fossil-fuel era means taking the road to an economy based on hydrogen manufactured from renewable resources. Thus, far, however, there are no appealing vehicles or any appropriate infrastructure for that task.

The optimistic assumption is that China offers an opportunity to break out of the vicious circle in which post-fossil-fuel automotive technology is trapped. It derives essentially from two points. First, technological path dependency is far less pronounced in China than in the triad countries. China has no comparably dense network of conventional fueling stations and workshops. Development of a new hydrogen infrastructure could be integrated "organically" into the profound dynamics of enlarging and converting the country's regions of megacities. This prospect is just as feasible for such advanced urban centers as Shanghai and Beijing (16 and 12 million inhabitants, respectively) as for recently built and aspiring cities with a populations of a million people. Hydrogen-based transport infrastructures could systematically fit into each of their master plans.

Second, the economic and ecological constraints are greater in China than in the triad countries. Stress on the environment is immense in China, especially in conurbations. Seven of the world's ten most polluted cities are located in China (Trinh, 2005). An unchecked escalation in the number and attendant emission levels of cars running on fossil-fuel would quickly lead to a chronic state of ecology emergency. Moreover, China depends heavily on oil, the consumption of which has soared as the economy has boomed. Unable to meet domestic need for crude oil from its domestic sources since 1995, the country now accounts for 9 percent of the world's total demand for this primary resource. With China's oil demand expected to double by 2020 (Zhu, 2005), China's economic dynamics, specifically the proliferation of cars that operate on fossil fuels, are inextricably linked to the price of crude oil on the world market.

The sense of a new beginning is liberating tremendous social energy, particularly in China's growth regions and the special economic zones on the coast. The visionary power of the Chinese dream and the will to be prosperous are moving mountains. Income is rising and is expected to grow by at least 5 percent annually until 2020 (Trinh, 2005). New technologies are hotly desired, not feared. And China has repeatedly demonstrated its ability to apply them with breathtaking speed, as with the high-speed train and the mobile communication network. Nonetheless, experts sharply disagree on assessments of China's future economic and geopolitical position and on predictions about future energy technologies or the availability of the different energy sources.

Some observers see China rising to become the world's leading power (Gabriel, 2006; Seitz, 2003; Sheff, 2002; Terrill, 2003); others forecast the country's descent into disorder and economic collapse (Chang, 2001; He, 2006; Heilmann, 2004; Hutton, 2006). Still others think that the Chinese automobile market will be strong and stable, whereas a different set of analysts fear that it is developing in a boom-and-bust cycle. Some people think hydrogen will be the basis of the twenty-first century's main technology in both the stationary and mobile realms; others are persuaded that this path of development will eventually prove to be a dead end. Some people do not expect a scarcity of fossil energies in the coming decades; others believe that the world has either already arrived at the point of maximal extraction or will reach it in a few years.

Policy goals and socioeconomic constraints

As formulated in 2002 and confirmed at the 17th party conference of the Communist Party of China five years later, the goal country's social policy by 2020 is to create *xiaokang* – a society with a modest level of prosperity for all. That means at least quadrupling the Chinese gross national product (GNP) within the 20 years from 2000 to 2020. The World Bank (2003, p. 17) has calculated that China will experience annual average economic growth of 7.2 percent and average annual income of 25,000 Renminbi Yuan (RMB)[1], or 3,000 US dollars ($), in 2020. Real development has been even more dynamic, at least thus far. China's urban working population already had an average annual income of RMB 21,000 in 2006 (Blume, 2007). The envisioned increases are not just pure chance. Ever since the inauguration of Deng Xiaoping's reforms, the nation has been exhorted to "be prosperous" and to expect that some people would get rich first and the others later.

Furthermore, the social policy objective of achieving modest prosperity for all is part of the Chinese dream of returning the country to the world role and position that the Chinese regard as befitting the legacy of human history's oldest continuous civilization. The Communist Party legitimates itself "as the trustee of the 'grand strategy'" (Herrmann-Pillath, 2005, p. 24), a function quite problematic for the party. As the guarantors of stability and order and as the driving force of the modernization process, China's leaders still enjoy almost universal acceptance by the population. Yet pressure for action and success in matters of economic performance is great (Bhaskaran, 2002). The promise of prosperity substantially raises the population's expectations, which then have to be met for the sake of political and social stability. The leadership must keep ensuring sufficiently high levels of growth while mitigating the socioeconomic problems that are arising or worsening with the transformation process. The government particularly fears what lurks in the ever more numerous local protests that have taken place for years – the mounting peril of social destabilization and unrest associated with rising rural unemployment (He, 2006). If the Communist Party does not manage to let its traditional constituency – the working masses – generally participate in the country's economic growth, it will lose its political legitimacy. China's leaders are fully aware of this danger. Unlike their predecessors over the generations, they openly address the problem and have made the fight against unemployment a high priority (Cai, 2006; Holbig, 2003).

Whereas urban unemployment is likely to decline because of unabatingly strong labor demand (Blume, 2007), rural unemployment will presumably remain high, probably well above 20 percent (Cai, 2006, p. 49). In agriculture alone, this assessment

means at least 150 million surplus workers. Another reason for such great pressure on the rural labor market is that both reorganization of the public business sector and the urgent need to raise productivity as a result of China's accession to the World Trade Organization in 2001 have uncovered hitherto hidden unemployment. The biggest medium-term issue on the Chinese labor market, however, is a demographic one. Although the gainfully employed population will shrink after 2025, the young people crowding onto the labor market outnumber the people retiring from it, so China's working-age population will grow by 100 million to total about one billion people by 2015 (European Commission, 2004). The divide that already exists between the number of jobs being created and the burgeoning number of new job-seekers will only widen. Still under construction, the country's social insurance system is inadequate and incapable of coping with the situation. With these facts in mind, the European Commission (2004, p. 306) states that "the political task to create an environment in which such an enormous number of new jobs can be created year by year is momentous."

Much of China's impressive economic growth continues to hinge on exports, which consist mostly of labor-intensive goods. Chinese exports account for a good deal of world trade in some categories, such as toys, consumer electronics, and textiles. Thanks to high foreign direct investment, much of what Chinese workers produce in more than 300,000 factories is for export. The value of the goods they made for the world market exceeded $970 billion in 2007 (Central Intelligence Agency, 2007). At times, foreign investment flowing into China since the early 1990s has constituted more than 5 percent of the country's gross domestic product and have totaled $70 billion annually in recent years. It is assumed that foreign companies and Chinese joint ventures with foreign participation produce about half of China's exports.

Technological performance

Chinese leaders know how crucial science and technology are to their country's competitiveness. They also know that sustained economic growth closely correlates with the ability to innovate. However, present levels of human capital, the scope and structure of R&D activities, and other cardinal factors of China's innovation system indicate that considerable effort and some time is needed before the country's capacity to innovate catches up with the developed nations.

Education is the cornerstone of that capacity in any country, an important indicator being the share of the population with a college education. Internationally, China ranks low on this score. It trails far behind the industrialized world in college graduates as a percentage of the total working-age population and in the rate of registered 20- to 24-year-old college students. The difference is conspicuous with regard to South Korea, a country that China tends to view as a model for its own process of economic modernization. Although the picture improves a bit upon consideration of the absolute numbers, high rates of growth, and great international mobility of Chinese students (Schaaper, 2004, pp. 33-8), the Chinese educational system does have its weaknesses, especially when it comes to quality and efficiency. Since the mid-1990s, China's Ministry of Education has, therefore, propagated a new educational concept, *suzhi jiaoyu* (quality education). The central idea is to complement traditional Chinese learning culture with western-style models of education and learning. Nationwide implementation of the reforms, however, requires appropriate teacher education

and a change in basic state regulations. After all, the values stated as the aims of "quality training" – creativity, abilities to innovate and analyze, and independence in the learning process, for example – "could alter the [given] political and ideological foundation, for these educational ideals call for a democratic and open climate in the classroom" (Seffert, 2003, p. 590).

An additional input into the capacity for innovation is R&D. In this area, too, there is still a yawning technological disparity between China and the organization for economic cooperation development (OECD) countries, as shown by R&D spending in relation to the GNP and by the absolute number of scientists. From 2001 to 2006, R&D spending in China rose from $12.6 to $37 billion, or from 0.95 to 1.45 percent of the GNP (Bundesagentur für Aussenwirtschaft, 2007), but China still unmistakably lags behind many other countries in this respect. The corresponding average percentage of R&D spending in the OECD countries is twice that level. Internationally, the country also compares poorly for its number of scientists in relation to the number of employees. Another problem is that the rights regulating the use of R&D results are largely unprotected in China. Substantial improvement in intellectual property rights and their enforcement will be essential for the innovative behavior of economic actors in that country and for the future development of a functioning innovation system there.

Catching up on modernization means eliminating backwardness and attain the relevant state of the art, whereas leapfrog modernization means vaulting beyond it by means of radical innovations. In the key sector of automotive manufacturing, these two paths of modernization, each with its specific and considerable demand for resources, entail different technological and infrastructural strategies. China's catch-up motorization is taking on a life of its own, threatening to overwhelm the absorption capacity of the country's booming conurbations and to push the national and global demand for crude oil to ominously high levels. On top of it all, runaway levels of noxious emissions are compounding the burden on the environment. As paradoxical as it sounds, further explosions in the car population in China will necessitate the ability to scale hypergrowth down to moderate balanced growth. But even if such moderation succeeds, the impacts of motorization – such as pollution and spatial problems in conurbations, reliance on oil imports, and dramatic levels of carbon dioxide – are expected to continue intensifying. The very success of automobility based on fossil fuels could bring this automotive development to its limits sooner than anticipated.

Verging on the dawn of the era after fossil fuels?

Because the operation of fossil-fuel vehicles can expand only so much, one can optimistically reason that levels of motorization surpassing those in developed countries is quite plausible in China, albeit perhaps not by 2020. The main argument is that the country already has the formal and informal institutions for a technological and industrial move into the era of energy sources other than fossil fuels. In principle, the country is positioned to leapfrog into it. The primary advantage is country's late entry into the deeply entrenched field of automotive manufacturing. Is thought possible for China to make a breakthrough in the automotive sector because it is more than ten years behind in conventional vehicle and engine design but presumably only two to five years behind in hybrid and hydrogen technologies. That difference in development can be made up if the nation's R&D resources are concentrated on the latter two lines of technology. Valuable know-how is already accumulating through

extensive experience from local field tests. The 2008 summer Olympic Games in Bejing and Expo 2010 in Shanghai are also expected to give alternative propulsion technologies a boost through the deployment of vast fleets of vehicles demonstrating the everyday use of hybrid and hydrogen engines. Above all, there is now heavy investment in supply infrastructure that can serve well beyond the period of these two major international events.

The strongest argument that China is able to develop the new engine technologies more quickly than the west can stems from the political decision-making structures and the breathtaking speed with which policy decisions are implemented in China. Free of complicated participatory and consensus-building procedures, they are quick and efficient. Authoritarian structures make for direct, focused action, with decisions being acted upon hierarchically without regard for the interests of individual citizens. This top-down approach is particularly rapid and successful when political determination comes to bear. Such will can be assumed for the issue of breaking through to the hydrogen economy.

Lastly, China has an internationally networked technical and economic elite. Many Chinese academics and managers are well connected in the scientific community of the triad countries. Having nurtured these contacts, they have become channels for the constant transfer of know-how. In addition, a great number of Chinese have returned from the triad countries, where they have studied, conducted research, and worked in international companies. They have brought their experience with modern management methods back to China. On the whole, then, conditions favor an automotive leapfrog. Catching up on motorization could become an exercise in overtaking the levels of motorization in other countries.

Growth policy and oil demand

Since the tumultuous phase of growth in recent years, China's leaders have tried to steer the country through a systematic transition from hypergrowth to balanced growth by 2020. The goal after that year is to achieve sustainable growth rooted in a technological lead over the triad countries. It is thus not only a matter of quantitatively reining in current hypergrowth but also of making a fundamental qualitative change in it, of moving it from low cost to highest tech. Snowballing dependence on cars in China shows how ambitious this growth policy is, for the system of motorization with automobiles that burn fossil-fuel might cease functioning before the advent of a system with those that do not. The resulting hiatus in automobility would be problematic because that mass motorization drives growth, generates purchasing power, instills initiative, stands for modernization, provides a vision of individual and collective action, and much more. An interruption in all these processes would be far more than just a sectorial setback in China's national economy.

The most critical point in this context is probably the availability and price of crude oil. China's growing need for this resource has a significant bearing on the rising worldwide demand for it and, hence, on the skyrocketing price in international markets. It is unclear how the efficiency of oil use can be improved to the point that demand for oil can be held constant or even reduced. Growth policy is thus caught in a conundrum. Diminished oil consumption jeopardizes China's economic growth and overall social stability, and growing oil consumption keeps edging prices up. Whether intended to catch up with or to surpass other countries, modernization projects nearly all more or

less hinge on oil. They, are therefore, indirectly endangered by soaring oil prices. In turn, the scope and continuity of funding for long-term basic research and technical projects are essentially a function of the level and stability of economic growth. In an attempt to counter this risk to growth policy, China's leaders have sought to secure the nation's long-term oil supply by buying into international oil companies and contracting directly with supplier countries such as Saudi Arabia, Iran, Russia, and Kaschstan.

If turmoil on the international oil markets is not to undercut automotive mobility in China, it will most likely be necessary to compel the transition from reliance on cars that run on fossil-fuel to those that do not. The task of technologically spanning the two modes becomes the priority. No matter what, however, two bridges between them are always a must, one for engine technology and one for infrastructure. Switching from vehicles powered by internal combustion or diesel systems to ones that employ hydrogen fuel cells or hydrogen batteries requires both a totally new kind of automobile engine and a completely new infrastructure for fueling and servicing. Engine technology and infrastructure cannot be developed in mutual isolation. This problem raises a typical question: Which comes first, the chicken or the egg? The technological bridge predicates the infrastructural one, and vice versa. If a transition from fossil-fuel to post-fossil-fuel automotive mobility occurs at all, it will be only through closely coordinated development of engine technology and infrastructure (Weider and Marz, 2005).

Transitions that have acquired the status of prototypical solutions in recent years are of interest. Five bridging technologies are involved:

(1) The hybrid internal combustion engine, has become quite popular of late. The most intriguing aspects are possible synergies between battery, hybrid, and fuel-cell vehicles. For example, both the development of an efficient battery and the development and design experience invested in a hybrid engine system can be used in later vehicles running on fuel cells. China has intensified its efforts to work with the market leader for hybrid technology, Toyota.

(2) The bridging technology that China is working on to move from fossil-fuel to post-fossil-fuel automotive mobility is the hydrogen-driven internal combustion engine. Hong Kong is conducting a project showcasing vehicles equipped with engines of that type built by Ford, and Beijing is testing out buses fueled by a mix of natural gas and hydrogen (hythane).

(3) The bridging technology, the reformer (methanol) option, has been ignored in China thus far. This lack of attention is understandable because methanol is a controversial fuel. Its merits are that it is liquid and that it can also be produced from coal. Its drawbacks are that it is poisonous and corrosive and that carbon dioxide forms during conversion. Nonetheless, a modified form of this approach could gain currency. Provinces rich in coal could, for example, manufacture methanol from it, which is less complicated than producing hydrogen from coal.

(4) The bridging technology, too, the internal combustion engine that takes compressed natural gas (CNG) or liquified petroleum gas (LPG), plays a subordinate role in China. For use in an internal combustion engine, natural gas must be either stored under high pressure or liquified. The latter process loses a great deal of energy. Although many CNG/LPG vehicles are in service, mostly in bus and taxi services, the costly and complicated storage technology is the crux of the issue.

(5) The bridging technology, synthetic fuel, has seen preliminary work in China, but a biofuel strategy poses problems largely because of the lay and unavailability of the country's agricultural land. Fully 38 percent of China's land is badly eroded, and 25 percent is desert. Only 15 percent of the nation's area is arable. Even that limited space will shrink, for it, too, is degenerating into steppe, and its most fertile areas lie where urbanization is rampant – in the river deltas. Moreover, China's requires ever more food for its population, which is expected to continue growing until 2020. Already unable to harvest enough soybean, rice, and wheat to meet its needs, the country imports these staples (Nolan, 2004; Trinh, 2005).

China faces a fundamental macroeconomic and technological decision on the direction of its policies. Given the multiple competing uses of the various bridging technologies and the indissoluble link between developments in engine technology and those in infrastructure, it is imperative to begin consolidating some of these alternatives and phasing out the others. Continuing to keep various options open will not lead to innovation but to stagnation. The contrasting technologies stymie rather than advance each other. The projects ought to be ranked and sequenced and the fragmented R&D capacities clustered more than they are. Local and regional centers of growth are needed in order to develop the fleets of vehicles and the infrastructure for mass motorization that does not depend on fossil fuels. Furthermore, the transition from fossil-fuel to post-fossil-fuel automotive mobility must be assigned higher social priority than it presently has. It could then be organized and pursued as a highly symbolic national project analogous to the Manhattan and Apollo projects of the twentieth century.

Modernization and the ambiguities of modern times

When it comes to identifying a potential path to mobility in China after the era of fossil-fuel, basic political, economic, and technical conditions are not the only important aspects to consider. There are cultural ones, too. In development theory, modernization encompasses more than the process of industrialization. Modernization as understood in the west is closely linked with the enlightenment, societal individualization, and the individual's internalization of collective constraints and role expectations. In western thinking, economic modernization and modernism belong together. To Weber (2004), leading one's life in a rational manner in the here and now is the twin brother of modern capitalism. Elias (1976, p. 313) sees the "internalization of external constraints" as both the characteristic of and the condition for modern ways of life. Modernism is the arena of society's struggle to shed the "self-inflicted disempowerment" (Kant, 1968, p. 53) suffered in bygone periods of religious paternalism and deprivation of self-determination. Yet it is precisely this modernism that encourages differentiation, accelerates, societal embedding, stretches the individual, and demolishes ostensible certainties.

The Chinese road to modernism has been followed now for a quarter of century. It is charted by the late-comer's tough resolve to catch up with the west and by cultural and institutional traditions (Seitz, 2003; Spence, 2001). For most of the last 2,000 years, China was technologically and organizationally the mightiest and most advanced civilization on Earth. Many "Western" inventions and key contributions to productivity – such as

the printing press, the magnetic compass, gunpowder, irrigation, and dietary medicine – were developed and used in China into the fifteenth century. Self-imposed isolation and rigid bureaucratic impasses made the Middle Kingdom miss out on modern analytical science and the industrial revolution (Needham, 1954). The country's resulting technical and economic backwardness became especially evident in the traumatic military defeats by western forces in the Opium Wars (1839-1842 and 1856-1860). In the first half of the twentieth century, a controversial discussion about the necessity of modernizing the country ensued in China from these experiences of inferiority in military technology and economic performance. They greatly motivated the communist revolutionaries and founders of the People's Republic. For decades, the problems of economic and technological development were pivotal for Mao Zedong and the Chinese Communist Party (Heberer, 2000). After Mao's death the supreme goal of the modernization program pursued by Deng Xiaoping was to become "'rich and strong' (*fu qiang*)" (Pohl, 2002, p. 111), like the west.

Confucian ethics and institutions informed by Confucian thought play a notable part in China's economic modernization, though it would be rash to speak of Confucian capitalism. Confucianism has a contradictory effect, favoring the appropriation of capitalism and its principles yet discouraging independent innovations. Current observers of East Asia's economic miracle see everyday Confucian ethics as affording an edge over other developing regions of the world in the process of catching up (Nutzinger, 2002; Schmidt, 2004). A salient element is Confucianism's high regard for education, initiative, prosperity, delayed gratification, and reverence of political and other kinds of authority. Clearly, such attributes and characteristics are commonly very conducive to economic development and compatible with East Asia's path to modernization, along which an authoritarian "developing state" (Heberer, 2000) figures as an agent of modernization.

However, what can be helpful in an early phase of adaptation can be obstructive in later stages of development in the modernization process. This contradictory effect is particularly apparent in the Confucian tradition of education, whose objective is the ability to reproduce a binding canon of knowledge. On the one hand, education is the "key in the chase to catch up" (Berger, 1996, p. 59). On the other hand, the monotonous penchant toward drill and memorization in the schools" (Schmidt, 2004, p. 193) proves to be a learning barrier at a higher level of education, for the ability and willingness to think independently are absent. The understanding of learning as reproduction is more important than the creative search for new solutions. Confucian thinking tends to be associated more with accommodation and culmination than with developmental discontinuities, which represent the other side of radical innovations.

Other elements checking the ability to innovate exist as well. One of them is Chinese society's vertical integration and vertical structures, which prevent, or at least hamper, the horizontal networking that helps bring forth innovations. A second hindrance is a tendency among Chinese firms to focus on short-term strategies and planning. Granted, such horizons permit quick adaptation to changing conditions but also lead to an inability to make major strategic transformations. Research investment and relatively large technological projects require long-term planning horizons. Lastly, the diagnosis that minds and ideas are being shared is overstated. Such circulation has so far been confined to the social and economic elite. If the international integration of scientists and managers is limited only to a small strata, no adequately broad

innovative culture is likely to form in China's research institutions and firms. In general, a fine-grained, hierarchical communication culture endures – the opposite of the top-down clout that people tend to praise as administrative efficiency.

The crucial thing is the notion of innovation as defined in the introduction of this paper. The ability to innovate calls for creativity, and these two capacities can flourish only in open societies. That message is the core of the modernization theory supported in this paper. The history of modernization is one of continually expanding opportunities for the individual to act, but it is also one of crises and intermittent groping for identity. Ambiguity is the sign of constantly modernizing modern societies.

Those wrenching ambiguities of modernization, however, are also the sources of creativity and innovation. Schumpeter (1979, p. 81) declared "creative destruction" to be the principle of progressive and successful capitalism. What fosters or interferes with creative destruction and concomitant individual and social creativity? All one can do to answer this question is point to general conditions, to characteristics of a societal deep structure that evidently favor the creation or effectiveness of creativity. Described in terms of sociological categories, they include a high degree of societal individualization and social mobility and a multitude of subcultural milieus and ways of life. Ordinarily, societal heterogeneity is fertile soil for cultural creativity and thus ultimately also for technological and economically useful investments. Social differentiation in this sense is the *sine qua non* of creative and innovative action in business, science, and culture alike.

The decisive aspect of this viewpoint is the empirical diagnosis that there is little or no individualization in Chinese society. This lack is considered a general handicap because the collective ability to produce independent innovations is thought to be associated with the presence of independent innovative milieus (Florida, 2004; Granovetter and Swedberg, 1992). Organizational sociology, which has dealt with innovation processes for decades, teems with examples of innovative configurations (Grabher and Powell, 2004). They boast great creativity and have a number of cultural and social prerequisites, including both a marked ability of their members to interact in highly integrated teams as well as in loosely linked networks, the absence of tightly graduated formal hierarchies, and high intrinsic motivation.

A centralized industrial and technology policy beyond sectors and the scramble for consensus is still possible in China. But because innovations consist of more than new technical infrastructures and mere imitations, they require decentralized spaces for incubation and experimentation. Translated into conditions governing the policy milieu, that need means that potential promoters of innovations need fundamental political freedoms, equality before the law, legal certainty, and the advancement and protection of personal rights *vis-à-vis* the state. Creativity cannot be decreed from on high, so skepticism about the chances for leapfrog motorization is convincing. Technologically beating the triad countries to an automotive hydrogen-based economy is not just about strong political will and efficient execution of policy. What is called for are social conditions that widely give rise to creativity and independent thinking and action as a matter of course. Without social modernization in the sense of differentiation, individualization, and internalization of external constraints, technical and economic modernization stays mired in convention.

Note

1. The Yuan-Euro exchange rate in 2007 was 10:1. The Chinese Yuan is officially called RMB (Renminbi Yuan), or CNY.

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